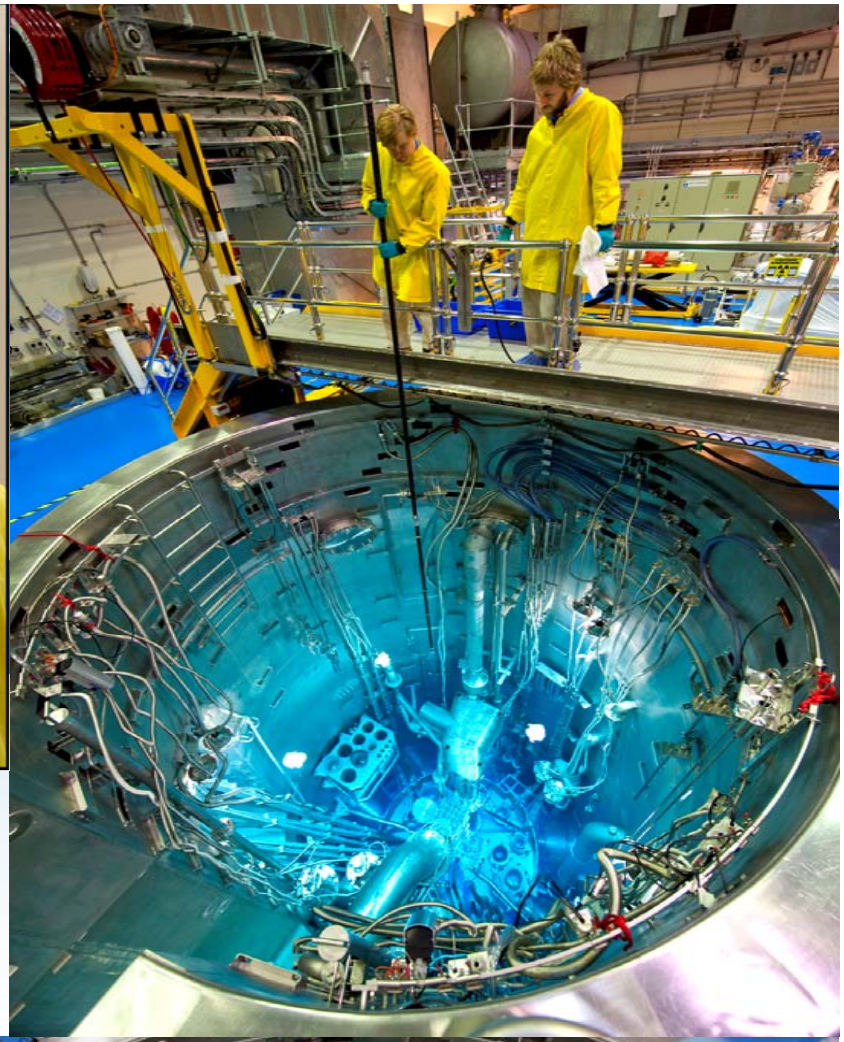
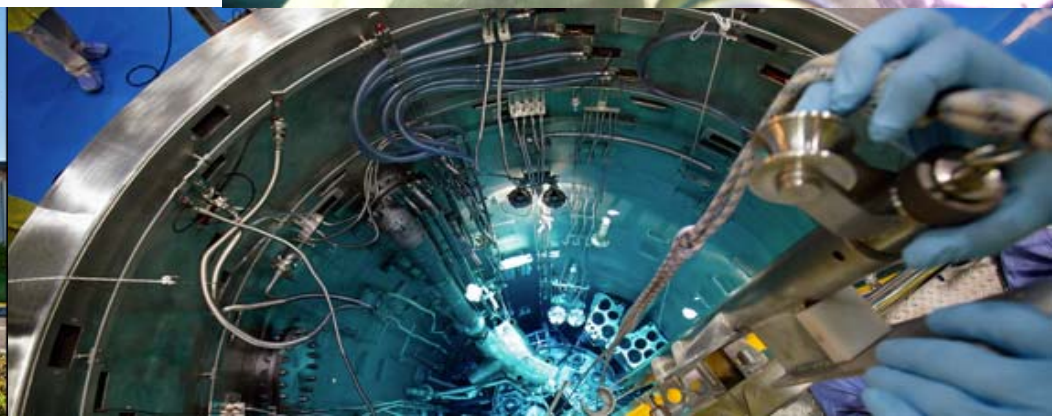
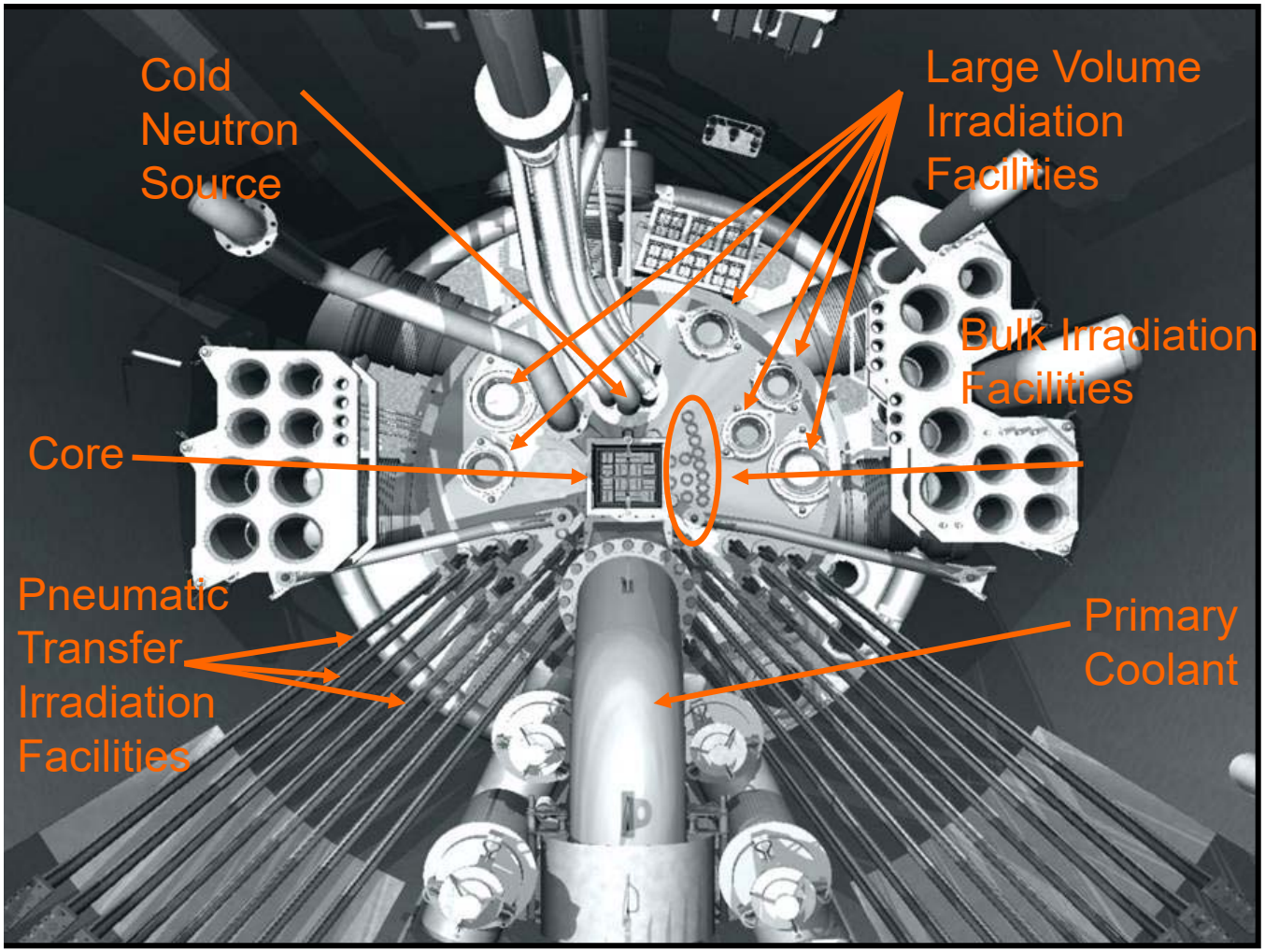


Irradiation Facilities of the OPAL Reactor



OPAL – Multipurpose

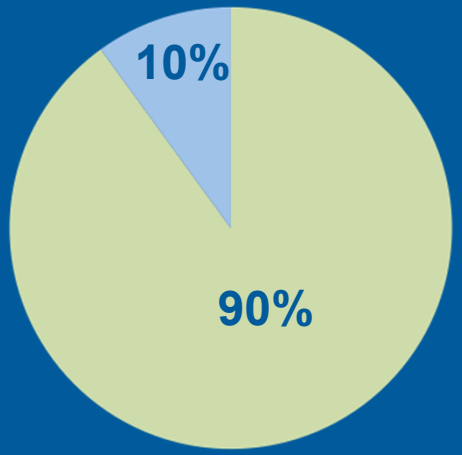


- Designed and Constructed by INVAP – Argentina
- 20 MW thermal power
- Compact core (~300 kW/L)
- Plate type – low enriched Uranium Fuel and Targets
- D_2O reflector
- Upward core coolant flow
- 2 independent & diverse shutdown systems

Neutrons – For Health

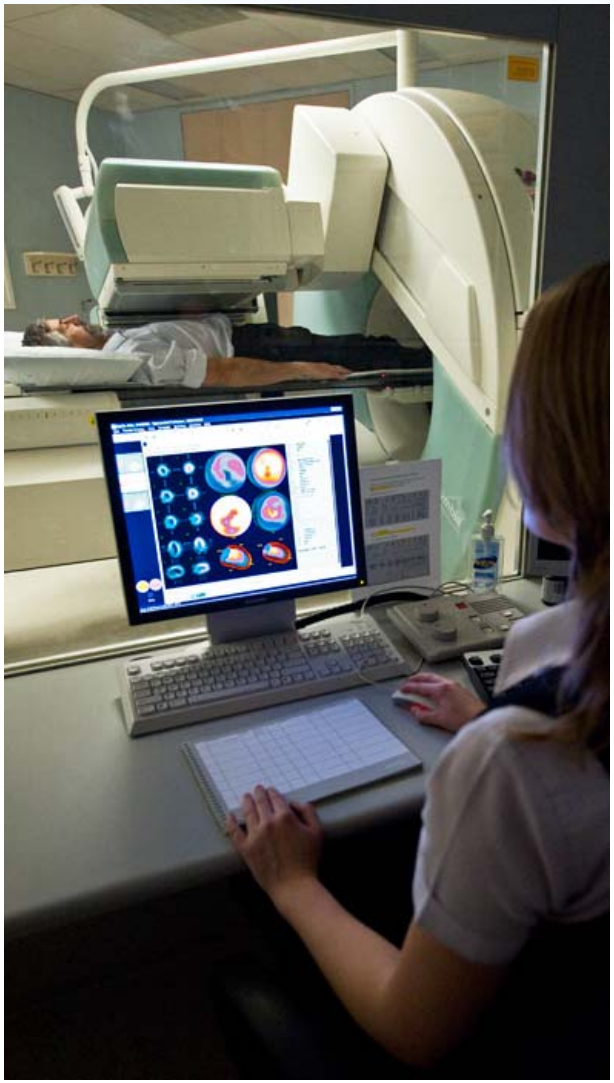
10,000 hospitals in the world use radioisotopes

40 million patients per year

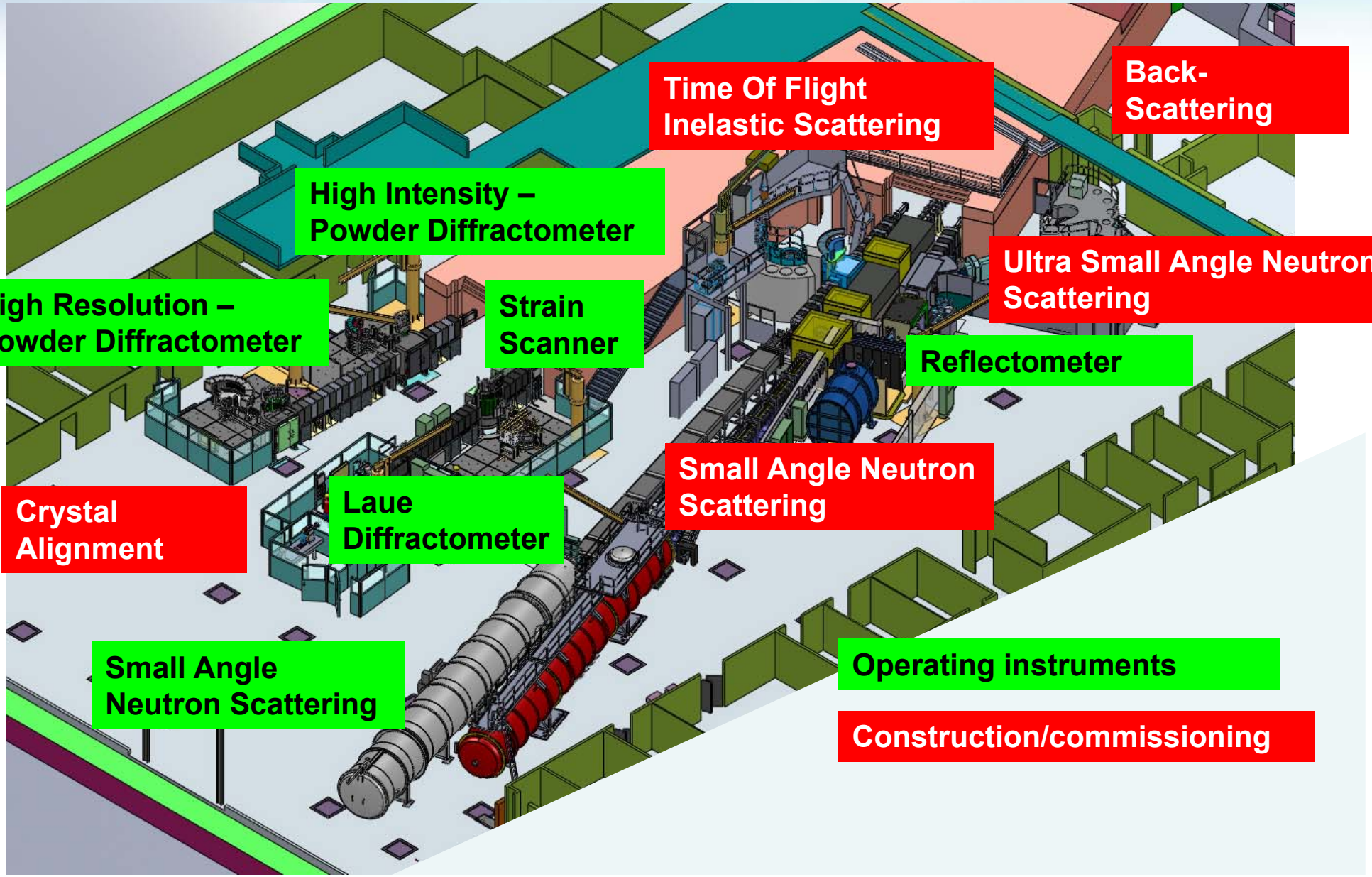


Diagnostics (cardiology, oncology, neurology)

Therapy / palliative care



Neutrons – for Science

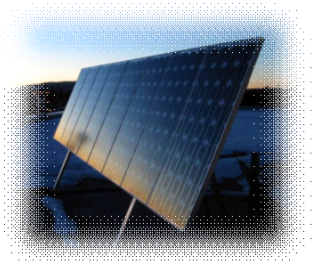


Neutrons – For Industry

NTD - Silicon

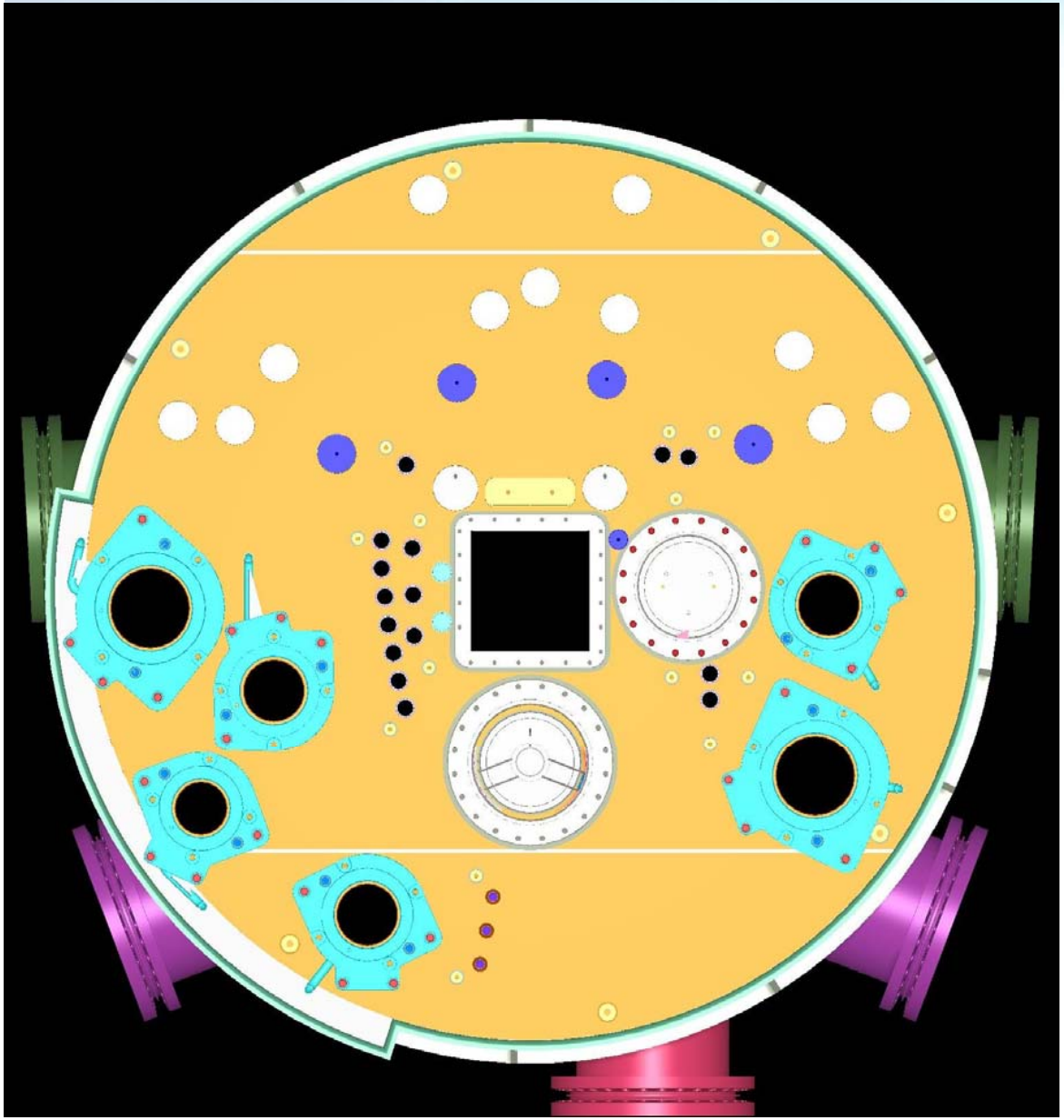
- High and very high voltage markets
- Low volume specialty products

- High and medium voltage markets
- Medium volume specialty products



Source: Topsil and Yole Development

Irradiation Facilities



- Bulk Production Irradiation Facilities.
- Long Residence Time General Purpose Irradiation Facilities (LRT).
- Short Residence Time Irradiation Facilities (SRT).
- Large Volume Irradiation Facilities (LVF).
- Hot Cells and Auxiliary Facilities.
- Interbuilding Pneumatic Transfer System (IPTS).

Irradiation Facilities and Target Considerations

- Target material containment/encapsulation
- Reactivity
- Irradiation conditions
- Physical target changes
- Cooling – forced and natural circulation
- Anchoring/fastening systems
- Handling of rigs and cans
- Rig Materials
- Neutron Flux perturbations
- Maintenance and Decommissioning

Key Safety Considerations

- Target power limit (W/target)
- Target heat flux limit (W/cm^2)
- Rig and target reactivity worth limit
- Uranium plate rig and target configuration
- Post irradiation decay time – activity and heat

Bulk Irradiation Facilities

Facility	Quantity	Flux (Thermal) $n/cm^2/s$	Utilisation
High Flux	2	Up to 2.9×10^{14} (peak)	• Iridium 192 – industrial use • Lutetium 177 (from Yb-176) • Other low volume commercial or research irradiations as capacity and financial considerations allow
Medium Flux	3	Up to 1.9×10^{14} (peak)	Iodine 131 by irradiation of Tellurium Dioxide – Thyroid disease diagnosis and treatment
Low Flux	12	Up to 1.1×10^{14} (peak)	Fission product Molybdenum 99 (by irradiation of LEU targets) which decays to Technetium 99m - Imaging

Bulk Irradiation Facilities

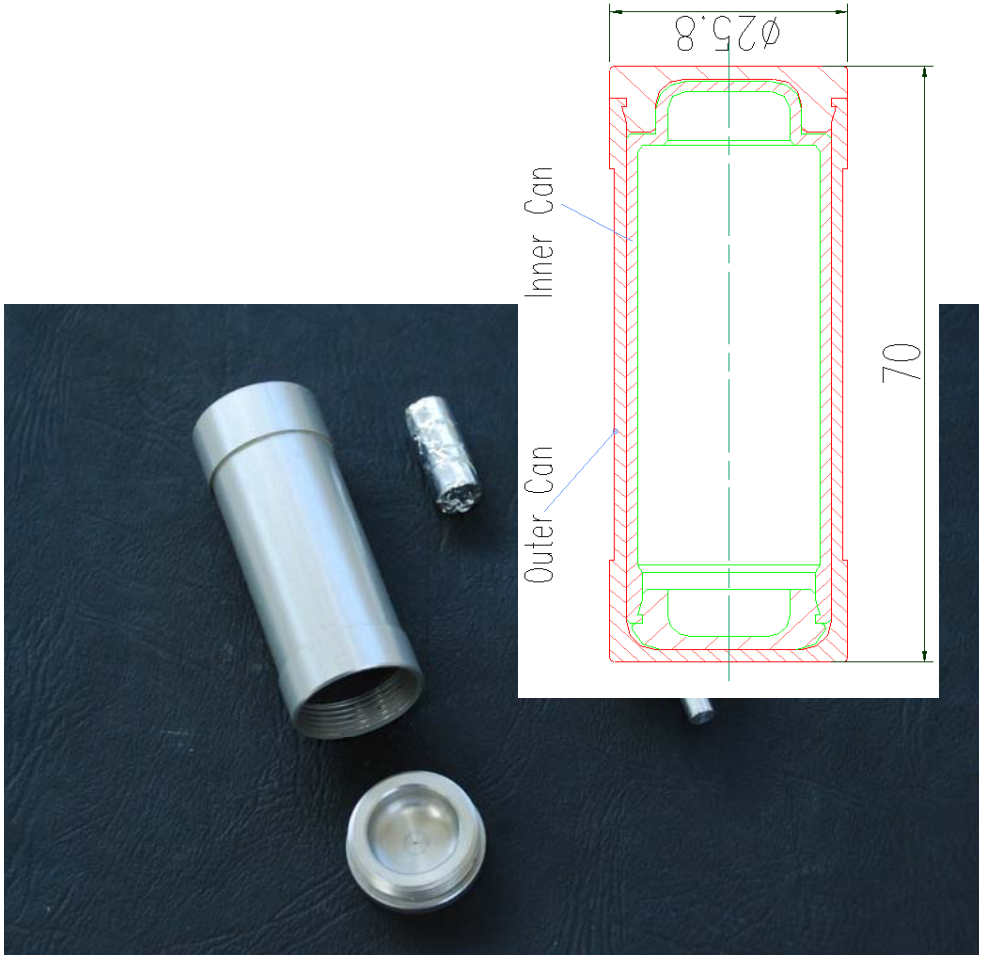
- Removal and replacement of bulk irradiation rigs is permitted with reactor at power (when < 200pcm)
- Downward coolant flow – pool water as coolant
- Rigs are 1.15 m long and 50 mm outer diameter

Long Residence Time Irradiation Facilities

Facility	Quantity	Flux Range (Thermal) $n/cm^2/s$	Utilisation
Long Residence Time - Thermal	49 irradiation positions	2×10^{12} to 1×10^{14}	• Chromium 51 – medical uses • Samarium 153 – pain management for bony metastases • Novel research targets and product development irradiations • Fission track samples – oil exploration industry • Geological samples – mining industry
Long Residence Time - Fast	6 irradiation positions	Fast flux > 7×10^{12} (with Cadmium lined cans)	Planning for Geochronology samples – dating studies

Long residence time Irradiation Facilities

- Removal and replacement of LRT targets is permitted with reactor at power (when < 40 pcm)
- Nitrogen for transfer and cooling
- Target cans – 25mm Outer diameter and 70 mm long
- Irradiation time from 1minute to 1 cycle



Short residence time Irradiation Facilities

Facility	Quantity	Flux Range (Thermal) $n/cm^2/s$	Utilisation
Short Residence Time	2 irradiation positions	6×10^{12} and 2.5×10^{13}	• Neutron Activation Analysis • Delayed Neutron Activation Analysis Supports research and various industries

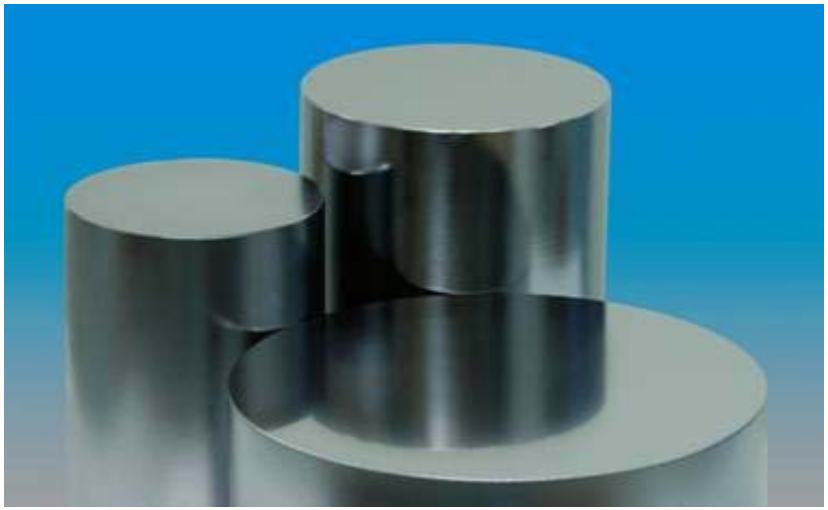
- Nitrogen for transfer and cooling
- Irradiated target automatically (pneumatically) transferred to Laboratory
- Target cans – high density polyethylene
- Irradiation time from 15 seconds to 15 minutes

Large Volume Irradiation Facilities

Facility	Quantity	Flux Range (Thermal) $n/cm^2/s$	Utilisation
Small 136 mm dia	1	3.5×10^{12}	Neutron transmutation doing of single crystal silicon 4 and 5 inch diameter
Medium 162 mm dia	3	1×10^{13} to 1.9×10^{13}	Neutron transmutation doing of single crystal silicon 4, 5 and 6 inch diameter
Large 213mm dia	2	3.2×10^{12} to 1×10^{13}	Neutron transmutation doing of single crystal silicon 2, 3, 6 and 8 inch diameter

Large Volume Irradiation Facilities

- Large volume rotating facilities
- 600mm total irradiation length
- Axial flux uniformity to ~2 to 5%
- Radial uniformity to ~5%



Stakeholder Engagement and the Reactor Schedule

- Schedule is set per calendar year by middle of previous year
- 300 days at power in a “typical” year
- Co-ordinate with other producers of Mo-99
- Allow for execution of the asset management program
- Requirements for shutdowns > 2 weeks are identified several years in advance
- Changes require re-engagement with all stakeholders

OPAL Reactor Schedule 2022

Issue Date 18/5/21

Rev 0

OPAL Shutdown

Public holidays

	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022
Mon								1				
Tue		1	1					2			1	
Wed		2	2			1		3			2	
Thur		3	3			2		4	1		3	1
Fri		4	4	1		3	1	5	2		4	2
Sat	1	5	5	2		4	2	6	3	1	5	3
Sun	2	6	6	3	1	5	3	7	4	2	6	4
Mon	3	7	7	4	2	6	4	8	5	3	7	5
Tue	4	8	8	5	3	7	5	9	6	4	8	6
Wed	5	9	9	6	4	8	6	10	7	5	9	7
Thur	6	10	10	7	5	9	7	11	8	6	10	8
Fri	7	11	11	8	6	10	8	12	9	7	11	9
Sat	8	12	12	9	7	11	9	13	10	8	12	10
Sun	9	13	13	10	8	12	10	14	11	9	13	11
Mon	10	14	14	11	9	13	11	15	12	10	14	12
Tue	11	15	15	12	10	14	12	16	13	11	15	13
Wed	12	16	16	13	11	15	13	17	14	12	16	14
Thur	13	17	17	14	12	16	14	18	15	13	17	15
Fri	14	18	18	15	13	17	15	19	16	14	18	16
Sat	15	19	19	16	14	18	16	20	17	15	19	17
Sun	16	20	20	17	15	19	17	21	18	16	20	18
Mon	17	21	21	18	16	20	18	22	19	17	21	19
Tue	18	22	22	19	17	21	19	23	20	18	22	20
Wed	19	23	23	20	18	22	20	24	21	19	23	21
Thur	20	24	24	21	19	23	21	25	22	20	24	22
Fri	21	25	25	22	20	24	22	26	23	21	25	23
Sat	22	26	26	23	21	25	23	27	24	22	26	24
Sun	23	27	27	24	22	26	24	28	25	23	27	25
Mon	24	28	28	25	23	27	25	29	26	24	28	26
Tue	25		29	26	24	28	26	30	27	25	29	27
Wed	26		30	27	25	29	27	31	28	26	30	28
Thur	27		31	28	26	30	28		29	27		29
Fri	28			29	27		29		30	28		30
Sat	29			30	28		30			29		31
Sun	30				29		31			30		
Mon	31				30					31		
Tue					31							
Wed												

This schedule is subject to change based on ANSTO's operational requirements